



PREFACE



The *Decision Maker's Guide to Solid Waste Management, Vol. II* has been developed particularly for solid waste management practitioners, such as local government officials, facility owners and operators, consultants, and regulatory agency specialists. The Guide contains technical and economic information to help these practitioners meet the daily challenges of planning, managing, and operating municipal solid waste (MSW) programs and facilities.

The Guide's primary goals are to encourage reduction of waste at the source and to foster implementation of integrated solid waste management systems that are cost-effective and protect human health and the environment.

Because the infrastructure and technology for handling MSW are rapidly changing, the information presented should help decision makers consider the numerous factors associated with successful implementation of new solid waste management solutions. Readers are encouraged to carefully evaluate all of the elements in their waste-handling systems and implement source reduction, recycling, and environmentally sound disposal.

Communities are encouraged to coordinate their goals for waste reduction and management, environmental protection, community development, and employment. Communities, businesses, institutions, and individuals should apply their creativity and ingenuity in drafting policies and designing programs that prevent the generation of waste in the first place. When waste generation is unavoidable, the materials can be viewed as a resource from which reusable materials, raw feedstock, minerals, organic matter, nutrients, and energy can be recovered for beneficial uses. Residual materials requiring disposal must be carefully managed to protect human health and the environment.

We encourage all individuals involved with MSW management to expand their professional skills and to help other practitioners and community members better understand the challenges we face and the opportunities available to us. It is primarily through such cooperative enterprises that governments, communities, and businesses can make the best possible decisions for the reduction and management of municipal solid waste.



From: *Decision Maker's Guide to Solid Waste Management, Volume II*, (EPA 530-R-95-023), 1995. Project Co-Directors: Philip R. O'Leary and Patrick W. Walsh, Solid and Hazardous Waste Education Center, University of Wisconsin-Madison/Extension. This document was supported in part by the Office of Solid Waste (5306), Municipal and Industrial Solid Waste Division, U.S. Environmental Protection Agency under grant number CX-817119-01. The material in this document has been subject to Agency technical and policy review and approved for publication as an EPA report. Mention of trade names, products, or services does not convey, and should not be interpreted as conveying, official EPA approval, endorsement, or recommendation.



PREFACE

(continued)

A Note on Using This Guidebook

For a quick overview of the issues covered in each chapter, readers are encouraged to review the highlights presented at the beginning of each chapter and the margin notes appearing throughout the Guide.

Disclaimer

This document was supported in part by the U.S. Environmental Protection Agency under grant number CX-817119-01. The material in this document has been subject to Agency technical and policy review and approved for publication as an EPA report. Mention of trade names, products, or services does not convey, and should not be interpreted as conveying, official EPA approval, endorsement, or recommendation.



ACKNOWLEDGMENTS

The Decision Maker's Guide to Solid Waste Management, Volume II was prepared under agreement between the Wisconsin Environmental Protection Agency (EPA) and the Solid and Hazardous Waste Education Center at the University of Wisconsin-Madison/Extension. The authors and their University of Wisconsin campus affiliations are shown below:

Philip R. O'Leary	Engineering Professional Development, UW-Madison
Patrick W. Walsh	Agricultural Engineering, UW-Madison
Robert K. Ham	Civil and Environmental Engineering, UW-Madison
Sherrie G. Gruder	Cooperative Extension, UW-Madison
Mary G Kohrell	Natural and Applied Science, UW-Green Bay
Holly J. Johnson	Natural Resources, UW-Stevens Point
Wayne Pferdehirt	Engineering Professional Development, UW-Madison
Aga S. Razvi	Solid Waste Management, UW-Stevens Point

Gary L. Boley authored Chapter 8, "Combustion." Additional materials were prepared by Andrew Swartz and Sue Waite. The document was edited and placed in camera ready-form by Christina Komadina. Jill McCulley and Meredith McIntosh assisted in proof reading the final document. Kris Winneke provided program support. The document was reviewed by staff of the Municipal and Industrial Solid Waste Division(MISWD.)

EPA and the authors wish to acknowledge the assistance of the following solid waste experts who served as a peer review team or prepared written reviews of individual chapters:

Kathy Berg Moeger	Minnesota Office of Waste Management, St. Paul, MN
Jan Beyea	National Audubon Society, New York City
Frank Cross	Cross/Tessitore & Associates, P.A., Orlando, FL
Diana Gale	Seattle Solid Waste Utility, Seattle, WA
Robert Glebs	Costain Resource Management, Inc., Madison, WI
Francis R. Gouin	University of Maryland at College Park, College Park, MD
Richard Hays	Waste Management Department, City of San Diego, CA
Timothy Hunt, Jr.	Solid Waste Authority of Palm Beach County, FL
Ronald Lofy	Lockman and Associates, Monterey Park, CA
William P. Moore	Paper Recycling International, Norcross, GA
John Nutter	American Recovery Corporation, Washington, D.C.
Ron Poland	Laidlaw Waste Systems, Burlington, Ontario
Paul Relis	Community Environmental Council, Santa Barbara, CA
Tom Richard	Cornell University, Ithaca, NY
Gary Sondermeyer	New Jersey Department of Environmental Protection, Trenton, NJ
Robert L. Spencer	Environmental Planning Consultants, Dalton, MA



CONTENTS

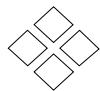
Preface	iii
Acknowledgments	v
Contents	vii
Figures	xix
Tables	xxii
Introduction	xxv
EMERGING ISSUES	xxvi
REFERENCES	xxvii

Chapter 1: Public Education and Involvement

INTRODUCTION	1-1
HIGHLIGHTS	1-2
A PUBLIC EDUCATION PLAN	1-3
Awareness	1-4
Interest	1-5
Evaluation	1-6
Trial	1-6
Adoption	1-8
Maintenance	1-9
INTRINSIC INCENTIVES	1-9
EXTRINSIC INCENTIVES	1-10
THE PUBLIC INVOLVEMENT PLAN	1-10
THE ISSUE EVOLUTION-EDUCATIONAL INTERVENTION (IEEI) MODEL	1-10
REFERENCES	1-13

Chapter 2: Facility Siting

INTRODUCTION	2-1
HIGHLIGHTS	2-2
THE SITING PROCESS	2-4
Creating a Siting Strategy	2-4
Who Is the Public?	2-4
Including the Public in the Process	2-7
Techniques for Involving the Public	2-8
Communicating Risks More Effectively	2-8
Building Credibility for Technical Information	2-13
Addressing Negative Impacts, Both Perceived and Real	2-14
Evaluating the Effectiveness of the Siting Strategy	2-14



CONTENTS (continued)

THE PERMITTING PROCESS	2-15
The Structure and Goals of the Permitting Process	2-15
Solid Waste Management Activities Requiring Permits	2-16
Source Reduction Programs	2-16
Recycling	2-16
Composting	2-16
Waste-to-Energy	2-17
Landfilling	2-17
Collection and Transport	2-17
REFERENCES	2-17

Chapter 3: Factors to Consider

INTRODUCTION	3-1
HIGHLIGHTS	3-2
DEVELOPING THE NECESSARY INFORMATION BASE	3-4
Identify Goals and Scope of the Program	3-4
Characterize Quantity and Composition of Material	3-4
MODELLING TECHNIQUES	3-5
Generic Weight Generation Data	3-5
Generation Rates For Specific Waste Types	3-6
Landfill Volume Estimates	3-7
PHYSICAL TECHNIQUES	3-8
Sampling Techniques	3-8
DIRECT MEASUREMENT TECHNIQUES	3-8
ESTIMATING THE PERCENTAGE OF MATERIAL THAT MUST BE MANAGED	3-9
Legal Control Over Waste Materials	3-9
Personal Waste Management	3-11
ESTIMATING FUTURE WASTE GENERATION	3-11
Gauging Program Participation and Effectiveness	3-11
ORGANIZING A WASTE MANAGEMENT PROGRAM	3-14
Planning	3-14
Price	3-15
Publicity	3-15
Politics	3-15
Perseverance	3-16
REFERENCES	3-16

Chapter 4: Collection and Transfer

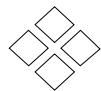
INTRODUCTION	4-1
HIGHLIGHTS	4-2
DEVELOPING A SOLID WASTE COLLECTION AND TRANSFER SYSTEM	4-5
DEFINING COMMUNITY GOALS AND CONSTRAINTS	4-5
CHARACTERIZING WASTE TYPES, VOLUMES, AND THE SERVICE AREA	4-6
PUBLIC AND PRIVATE COLLECTION/TRANSFER: DETERMINING OPTIONS	4-6



CONTENTS

(continued)

DETERMINING THE SYSTEM FUNDING STRUCTURE	4-7
IDENTIFYING WASTE PREPARATION AND COLLECTION PROCEDURES	4-10
Solid Waste Set-Out Requirements	4-10
Storage Container Specifications	4-10
Solid Waste Separation Requirements	4-11
Frequency of Collection	4-11
Pick-up Points for Collection	4-11
DETERMINING COLLECTION EQUIPMENT AND CREW SIZE	4-13
Selecting Collection Equipment	4-13
Equipment Types	4-13
Criteria for Equipment Selection	4-14
Crew Size	4-14
EVALUATING TRANSFER NEEDS AND OPTIONS	4-14
Evaluating Local Needs for Waste Transfer	4-16
Types of Transfer Stations	4-16
Small to Medium Transfer Stations	4-16
Larger Transfer Stations	4-17
Direct-Discharge Noncompaction Stations	4-17
Platform/Pit Noncompaction Stations	4-18
Compaction Stations	4-19
Transfer Station Design Considerations	4-19
Site Location and Design Criteria	4-19
Building Design	4-20
Transfer Station Sizing	4-20
Additional Processing Requirements	4-23
Transfer Vehicles	4-24
Trucks and Semitrailers	4-24
Rail Cars	4-24
EVALUATING COLLECTION AND TRANSFER ALTERNATIVES	4-26
Defining System Alternatives	4-26
Comparing Alternative Strategies	4-26
Analyzing Crew and Truck Requirements	4-26
Estimating Time Requirements	4-27
Loading Time Requirements	4-27
Hauling Time and Other Travel Time Requirements	4-27
Overall Time Requirements	4-28
Analyzing Transfer Elements	4-28
Selecting A Collection and Transfer Alternative	4-28
DEVELOPING COLLECTION ROUTES AND SCHEDULES	4-30
Heuristic Route Development: A Manual Approach	4-31
Computer-Assisted Routing	4-32
IMPLEMENTING THE COLLECTION AND TRANSFER SYSTEM	4-32
Finalizing and Implementing the System Management Plan	4-32
Purchasing and Managing Equipment	4-33
Equipment Purchasing	4-33
Equipment Maintenance	4-33
Equipment Replacement	4-34
Hiring and Training Personnel	4-34
Safety	4-34
Comfort	4-35
Training	4-35



CONTENTS

(continued)

Worker Incentives	4-35
Developing and Managing Contracts with Labor Unions and Private Collectors	4-36
Providing Public Information	4-36
MONITORING SYSTEM COSTS AND PERFORMANCE	4-37
REFERENCES	4-37

Chapter 5: Source Reduction

INTRODUCTION	5-1
HIGHLIGHTS	5-2
UNDERSTANDING AND FOSTERING SOURCE REDUCTION	5-5
Defining Source Reduction	5-5
Source Reduction as a First-Choice Approach	5-6
Measuring Source Reduction	5-6
SOURCE REDUCTION POLICY	5-7
Regulation	5-7
Economic Incentives and Disincentives	5-9
GOVERNMENT SOURCE REDUCTION	5-10
Facility Source Reduction Programs: Performing Waste Audits	5-10
Purchasing	5-11
COMMERCIAL (INDUSTRIAL AND BUSINESS) SOURCE REDUCTION	5-13
Source Reduction Implementation Guidelines For Industries	5-14
Manufacturing Redesign	5-14
Product Redesign	5-14
Other Industrial Source Reduction Strategies	5-15
Designing for Durability	5-15
Designing for Reuse	5-15
Designing Products to Facilitate Repair	5-15
Source Reduction Implementation Guidelines For Businesses	5-15
Other Examples of Source Reduction and Reuse by Businesses	5-17
SOURCE REDUCTION BY RESIDENTS	5-18
Local Source Reduction Economic Incentives: Unit-Based Garbage Fees	5-18
Yard Material Reduction	5-19
Consumer-Based "Precycling" or "Eco-Shopping"	5-20
REFERENCES	5-22

Chapter 6: Recycling

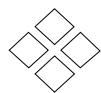
INTRODUCTION	6-1
HIGHLIGHTS	6-2
DEVELOPING A RECYCLING PROGRAM: A SYSTEMS APPROACH	6-6
USING EXISTING RESOURCES	6-6
Cooperative Recycling	6-7
DESIGNING AND IMPLEMENTING A RECYCLING PROGRAM	6-7
Assess Markets and Market Development Strategies for Recyclables	6-8
STRUCTURE OF THE RECYCLABLES MARKET	6-8
Market Structure	6-9



CONTENTS

(continued)

Collectors/Haulers	6-9
Processors	6-9
Brokers	6-9
Converters	6-9
End-Use Markets	6-9
Transportation Companies	6-10
Material-Specific Market Structure	6-10
Paper	6-10
Glass	6-11
Plastic	6-11
Metals	6-12
Tires	6-12
ASSESSING MARKETS	6-13
Identifying Buyers	6-14
Contacting Buyers	6-14
Selecting Buyers	6-15
Contracting with Buyers	6-15
ANTICIPATED CHANGES IN U.S. AND EXPORT MARKETS	6-16
ASSESSING MARKET DEVELOPMENT INITIATIVES	6-17
Legislative Options	6-17
Economic Incentives	6-19
Technology Developments and Improvements	6-20
Transportation Networks	6-21
Business Development	6-22
Education Strategies	6-23
Cooperative Marketing	6-24
ASSESSING AND CHOOSING COLLECTION AND PROCESSING TECHNOLOGIES	6-24
Ways to Collect Recyclables	6-24
Residential Waste Drop-Off and Buy-Back Collection	6-24
Curbside Collection Options	6-25
Source Separation	6-25
Mixed-Waste Collection	6-25
Wet/Dry Collection	6-27
Combined Collection Options	6-27
Collection Schedule	6-28
Business and Bulky Waste	6-28
Waste from Retail Businesses	6-28
Waste from Restaurants and Bars	6-29
Institutional Waste	6-29
Wood and Construction/Demolition Material	6-30
Appliances	6-30
OPERATIONAL ISSUES	6-30
Collecting Recyclables	6-30
Collecting Residential and Commercial Waste	6-32
Special Collection Problems	6-33
PROCESSING/STORAGE CENTER DESIGN	6-33
Site Location	6-34
Area	6-35
Scale	6-35
Building Design: Outside-Inside Interface	6-35
Tipping or Unloading Area	6-35



CONTENTS

(continued)

Storage Area	6-39
Building Structure	6-39
Employee and Education Facilities	6-39
Hazardous Materials Area	6-39
Building Layout and Equipment Choices: Manpower Versus Machines	6-40
Conveyor Line	6-41
Processing and Densifying Equipment	6-41
Handling Equipment	6-43
Redundancy	6-44
DEVELOPING AN ORGANIZATIONAL PLAN AND BUDGET	6-44
Organization	6-44
Budget	6-45
Financing	6-45
ADDRESSING LEGAL SITING ISSUES	6-45
Zoning and Land Use Considerations in Siting	6-47
Building Codes	6-47
Permits	6-47
Contracts	6-47
General Business Regulation	6-47
Ordinances	6-48
DEVELOPING A START-UP APPROACH	6-48
Pilot Programs	6-49
Voluntary Recycling	6-49
Mandatory Recycling	6-50
IMPLEMENTING THE EDUCATION AND PUBLICITY PROGRAM	6-50
BEGINNING PROGRAM OPERATION	6-51
CONTINUING SUPERVISION, LONG-TERM PUBLICITY AND EDUCATION	6-51
REVIEWING AND REVISING PROGRAMS TO MEET CHANGING NEEDS	6-52
REFERENCES	6-52

Chapter 7: Composting

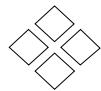
INTRODUCTION	7-1
HIGHLIGHTS	7-2
WHAT IS COMPOSTING?	7-8
Composting as a Biological Process	7-8
Composting as a Component of Integrated Solid Waste Management	7-9
The Benefits of Composting	7-9
Composting Challenges	7-10
THE BIOLOGICAL, CHEMICAL, AND PHYSICAL COMPOSTING PROCESSES	7-10
Biological Processes	7-11
Chemical Processes	7-11
Carbon/Energy Source	7-12
Nutrients	7-12
Moisture	7-12
Oxygen	7-13
pH	7-13
Physical Processes	7-14



CONTENTS

(continued)

Particle Size	7-14
Temperature	7-14
Mixing	7-15
AN OVERVIEW OF COMPOSTING APPROACHES	7-15
Grasscycling and Backyard Composting	7-15
Grasscycling	7-15
Backyard Composting	7-15
Source-Separated Organics Composting Programs	7-16
Mixed Municipal Solid Waste Composting	7-17
DEVELOPING A COMPOSTING PROGRAM	7-17
Evaluating Waste Management Alternatives	7-17
Planning the Program	7-17
Identifying Composting Project Goals	7-18
Obtaining Political Support for a New Waste Management Approach	7-19
Identifying Potential Compost Uses and Markets	7-19
Inventorying Potential Sources of Compostable Materials	7-19
Initiating Education and Information Programs	7-20
Choosing a Composting Approach	7-21
Compatibility with Existing Programs	7-21
Selecting Appropriate Technologies and Systems	7-21
COMPOSTING TECHNOLOGIES	7-22
Windrow Composting	7-22
Aerated Static Pile Composting	7-23
In-Vessel Composting Systems	7-24
Anaerobic Processing	7-25
Screening	7-26
Curing	7-26
MARKETING COMPOSTS	7-27
Marketing Strategies	7-27
Education, Research, and Public Relations	7-28
Potential Compost Uses	7-28
Compost Quality—Impacts on Uses and Markets	7-31
Quality Control	7-33
Manufacturing Multiple Products	7-33
Inventorying Potential Markets	7-33
Distributing Compost	7-34
Pricing	7-34
Finalizing Market Arrangements	7-35
COMPOSTING APPROACHES IN DETAIL	7-35
Grasscycling	7-35
Backyard Residential Composting	7-37
Process Description	7-37
Implementation	7-37
Public Education	7-37
Financial Support	7-37
Yard Trimmings Composting Programs	7-39
Collection	7-39
Drop-Off Sites	7-39
Curbside Collection	7-40
Combined Approaches	7-41
Preparing Yard Trimmings for Composting	7-42



CONTENTS

(continued)

Applicable Composting Technologies	7-42
Processing for Markets	7-43
Product Characteristics of Yard Trimmings Compost	7-43
Direct Land-Spreading of Yard Trimmings	7-44
Source-Separated Organics Composting	7-45
Waste Collection	7-45
Preparing Materials for Composting	7-47
Applicable Composting Technologies	7-47
Processing for Markets	7-47
Product Characteristics of Source-Separated Organics Compost	7-47
Mixed MSW Composting Systems	7-47
Collection	7-47
Preparing Materials for Composting	7-48
Applicable Composting Technologies	7-49
Processing for Markets	7-51
Product Characteristics of Mixed MSW Compost	7-51
OPERATIONAL CONSIDERATIONS AND CONCERNS	7-52
Housekeeping	7-52
Leachate	7-52
Odor Control	7-52
Personnel	7-53
Monitoring	7-53
Record Keeping	7-54
Public Information	7-54
Complaint Response Procedure	7-55
FACILITY SITING	7-55
GOVERNMENT APPROVALS, PERMITS, AND ORDINANCES	7-56
PROJECT FINANCING	7-56
REFERENCES	7-57

Chapter 8: Combustion

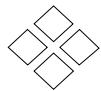
INTRODUCTION	8-1
HIGHLIGHTS	8-2
THE IMPLEMENTATION PROCESS	8-7
Project Development Team	8-8
PROJECT DEFINITION: IDENTIFYING GOALS	8-8
ASSESSING PROJECT FEASIBILITY	8-9
Assess Political and Citizen Support	8-9
Evaluate Waste Sources	8-9
Waste Composition	8-9
Coordination with Other Waste Management Practices	8-10
Waste Reduction	8-10
Source Separation of Nonrecyclable and Hazardous Materials	8-10
Recycling	8-11
Composting	8-11
Landfilling	8-12
What Area Will Be Served?	8-12
ENERGY AND MATERIAL MARKETS	8-12



CONTENTS

(continued)

Energy Market Options	8-12
Electricity Only	8-13
Steam	8-13
Co-Generation	8-14
Refuse-Derived Fuel (RDF)	8-14
Energy Contract Issues	8-16
Price	8-16
Service and Schedule	8-16
Reliability	8-16
Material Markets	8-16
THE COMBUSTION PROCESS AND TECHNOLOGIES	8-17
Technology Options	8-17
Modular Systems	8-17
Mass-Burning Systems	8-22
Refuse-Derived Fuel (RDF) Systems	8-23
Shred-and-Burn Systems	8-24
Simplified Process Systems	8-24
RDF Combustors	8-25
Incinerator System Components	8-27
Storage and Handling Area	8-28
Waste Combustion System	8-28
Energy Conversion and Use	8-28
Residue Control	8-28
Emission Controls	8-28
Volatile Organic Controls	8-29
Nitrous Oxide (NO_x) Controls	8-29
Acid Gas Controls	8-29
Particulate Controls	8-29
Secondary Volatile Organic and Mercury Control	8-31
Emission Monitoring	8-31
ENVIRONMENTAL PERMITTING	8-31
Air Permit Regulations	8-31
New Source Performance Standards (NSPS)	8-32
Best Available Technology	8-32
Operator Certification	8-32
Co-Fired Facility	8-32
"Prevention of Significant Deterioration" (PSD) Determination	8-33
New Source Review (NSR) Permit	8-34
Lowest Achievable Emission Rate	8-34
Offsets	8-34
State Implementation Plan (SIP)	8-34
Federal Emission Standards	8-35
Residual Disposal	8-35
Water Discharge	8-36
Surface Water Concerns	8-36
Groundwater Concerns	8-36
Local and Other Federal Program Requirements	8-36
Public Utilities Regulatory and Policy Act (PURPA)	8-36
Federal Aviation Administration (FAA)	8-37
Other Environmental Issues	8-37
Land-Retained Pollutants	8-37
Noise Pollution	8-37



CONTENTS

(continued)

Aesthetic Impacts	8-37
Land Use Compatibility	8-37
Environmentally Sensitive Areas	8-38
Health Risk Analysis	8-38
Role of the Contractor in the Permitting Process	8-38
Regulatory Approval Summary	8-38
SITE SELECTION	8-38
Map Overlay Technique For Potential Sites	8-39
Detailed Site Evaluation	8-40
RESPONSIBILITY FOR FACILITY OPERATION	8-40
Public Operation	8-41
Private Operation	8-41
METHOD OF FINANCING	8-41
General Obligation (G.O.) Bonds	8-42
Municipal (Project) Revenue Bonds	8-42
Leverage Leasing	8-42
Private Financing	8-42
RISK-TAKING POLICY	8-43
PROCUREMENT APPROACHES	8-43
The Architect/Engineer Approach	8-43
The Turnkey Approach	8-44
The Full-Service Approach	8-44
CONSTRUCTION AND OPERATION PHASE	8-44
REFERENCES	8-44

Chapter 9: LAND DISPOSAL

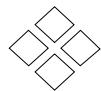
INTRODUCTION	9-1
HIGHLIGHTS	9-2
LANDFILLING—AN OVERVIEW	9-9
NEW LANDFILLS	9-11
EXISTING OR CLOSED LANDFILLS	9-11
DEVELOPING AN INFORMATION BASE AND MAKING INITIAL SITE DECISIONS	9-12
Estimate Landfill Volume Requirements	9-12
Conduct Initial Investigation and Select Potential Sites	9-14
Starting the Project	9-15
Fulfilling Land Use Goals	9-15
Using Soil Maps in Selecting Potential Sites	9-16
Tabulating Site Identification Data	9-17
Determine Applicable Federal, State, and Local Requirements	9-18
The Resource Conservation and Recovery Act (RCRA)	9-18
State and Local Requirements	9-19
Additional Concerns	9-19
Assess Landfill Options for Energy and Materials Recovery	9-19
Consider Final Site Use	9-20
Determine Suitability of Sites	9-21
Conducting Site Characterizations—Information Collection and Review	9-21
Conducting Site Characterizations—Field Investigations	9-21



CONTENTS

(continued)

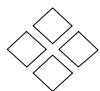
DEVELOPING THE FACILITY DESIGN	9-24
Preliminary Considerations	9-24
Selecting the Type of MSW Landfill	9-24
The Design Process	9-25
Public Participation in the Site Selection Process	9-26
Meeting Regulatory Standards	9-26
General Design Considerations	9-28
Plans and Specifications	9-28
Design Report	9-28
Public Involvement	9-28
State-Level Approval Process	9-28
Additional Requirements	9-28
Developing the Site Layout	9-28
Preparation of Drawings	9-29
Operating Plans	9-30
Determining Working Face and Phase Dimensions	9-30
Phase Diagrams	9-31
Leachate Management	9-32
Factors Affecting Leachate Generation	9-33
Predicting Leachate Production Rates	9-34
Regulatory Controls for Leachate Management	9-36
Landfill Liner System Components	9-37
Clay Liners	9-37
Flexible Membrane Liners	9-37
Leachate Collection Systems	9-38
Leachate Treatment Processes	9-39
The Natural Attenuation of Leachate	9-41
Groundwater Quality Assessment	9-41
Monitoring Wells	9-41
Groundwater Monitoring and Corrective Action	9-41
Gas Management	9-43
Why Gas Control is Needed	9-43
The Mechanics of Gas Movement	9-44
Controlling Gas	9-45
Gas Probes	9-45
Gas Control Systems	9-46
Passive Gas Control Systems	9-46
Active Gas Collection Systems	9-46
Collecting Gas for Beneficial Use	9-47
Methods of Energy Recovery	9-48
Final Cover System	9-49
Design Considerations	9-50
Erosion Control	9-50
Vegetation	9-50
Other Design Considerations	9-51
Roads	9-51
Storm Water Drainage	9-52
Utilities	9-52
Scales	9-52
Regulatory Approvals	9-52
OPERATING THE LANDFILL	9-53
Providing Financial Assurance	9-53
Program to Detect and Exclude Hazardous Waste	9-53



CONTENTS

(continued)

Inspections	9-54
Alternative Methods for Detection and Prevention	9-54
Cover Material Requirements	9-54
Air Criteria	9-54
Access Control	9-55
Run-on and Runoff Control Systems	9-55
Small Vehicles and Safety	9-55
Additional Controls	9-55
Landfill Equipment	9-56
Waste Handling and Compaction	9-58
Waste Shredding	9-58
Baling Solid Waste	9-59
Landfill Handling and Compaction Equipment	9-59
Earth Movers	9-59
Equipment Maintenance and Backup	9-59
Adverse Weather	9-59
Personnel and Safety	9-60
Quality Control and Record Keeping	9-60
Community Relations	9-61
CLOSING THE LANDFILL AND PROVIDING POST-CLOSURE CARE	9-61
Financial Assurance for Closure and Post-Closure Care	9-61
Procedures for Site Closure	9-62
Post-Closure Care	9-63
General Upkeep	9-63
Road and Drainage Structure Repairs	9-63
Leachate Treatment	9-63
Groundwater Quality Monitoring	9-64
Landfill Gas Monitoring	9-64
REFERENCES	9-64
Appendix A: Glossary	A-1
Appendix B: Municipal Solid Waste Publications	B-1



FIGURES



Introduction

Figure Number	Page
I-1 Hierarchy of Integrated Solid Waste Management	xxvii

Chapter 1: Public Education and Involvement

1-1 Household Hazardous Materials Program	1-4
1-2 Dinosaur Symbol Used on Recycling Materials to Enhance Appeal of Mandatory Programs	1-5
1-3 Example of Public Education Flyer	1-7
1-4 Sample Education Program	1-8
1-5 Example of Material Encouraging Feedback on a Recycling Program	1-9
1-6 Issue Evolution/Educational Intervention Model	1-12

Chapter 2: Facility Siting and Permitting

2-1 The Three-Phase Siting Framework	2-5
2-2 Levels of Involvement by Various Segments of the Public	2-6

Chapter 3: Developing a Waste Management Program—Factors To Consider

3-1 Landfill Volume of Materials in MSW, 1990	3-7
-----------------------------------------------------	-----

Chapter 4: Collection and Transfer

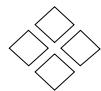
Chapter 4 has no figures

Chapter 5: Source Reduction

5-1 Cartoon	5-12
-------------------	------

Chapter 6: Recycling

6-1 Uses of Scrap Tires	6-13
6-2 Examples of Stickers Indicating Why Waste Was Not Picked Up	6-25
6-3 Office Paper Recycling Containers	6-29
6-4 Material Flow Chart for Wood Waste Management	6-30
6-5 Newspaper Rack for Rear-Loading Collection Vehicle	6-32
6-6 Source Separation Collection Truck	6-32
6-7 Rural Container Station	6-34
6-8 Recycling Center, Toledo, Ohio	6-36
6-9 Recycling Revetments	6-36
6-10 Material Recycling Facility Site Plan and Traffic Flow	6-37



FIGURES (continued)

Figure Number	Page
6-11 Facility Layout, Dupage County, North Intermediate Processing Facility	6-40
6-12 Medium and High Technology Processing	6-42

Chapter 7: Composting

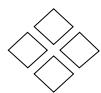
7-1 The Composting Process	7-8
7-2 Windrow Composting With an Elevating Face Windrow Turner	7-23
7-3 Aerated Static Pile for Composting Municipal Solid Wastes	7-24
7-4 Anaerobic Digestion With Aerobic Compost Curing	7-25
7-5 Grass Being Mowed and Returned to the Lawn for Grasscycling	7-36
7-6 Yard Trimmings Composting Units	7-38
7-7 Example of Yard Trimmings Composting Facility Site Layout	7-44
7-8 Example of Source Separated Organics Composter Material Flow and Mass Balance	7-48
7-9 Example of Mixed MSW Composter Material Flow and Mass Balance	7-50
7-10 Lead Concentrations in Various Types of Compost	7-51

Chapter 8: Combustion

8-1 Project Definition and Development Plan	8-7
8-2 Typical Monthly Waste Generation and Energy Demand Patterns	8-11
8-3 Incinerator and Electrical Generation System	8-13
8-4 Co-generation System for Producing Electricity and Steam	8-15
8-5 Combustion Excess Air Versus Combustion Gas Temperature	8-17
8-6 Typical Mass-Burn Facility Schematic	8-22
8-7 Typical Simplified RDF Facility Schematic	8-25
8-8 Typical RDF Stocker and Boiler	8-26
8-9 Typical Mass-Burn System Design Basis	8-27
8-10 Spray-Dry Scrubber and Baghouse	8-30
8-11 Baghouse Schematic	8-30
8-12 Waste-to-Energy Facility Siting Map Overlay Example	8-39

Chapter 9: LAND DISPOSAL

9-1 Schematic of a Typical Municipal Solid Waste Landfill	9-10
9-2 Examples of Map Overlays	9-17
9-3 Example of Soil Boring Logs	9-23
9-4 Example of Groundwater Contour Map	9-24
9-5 The Area Method of Sanitary Landfilling	9-25
9-6 Subsurface Conditions Along a Cross Section of a Landfill Under Construction	9-29
9-7 Solid Waste Placement and Compaction	9-31
9-8 Landfill Construction Plan: Intermediate Phase	9-32
9-9 Phases of Solid Waste Decomposition	9-32
9-10 Water Balance Equation	9-34
9-11 Types of Landfill Liners	9-38
9-12 Typical Leachate Collection System Showing Access to Pipes for Cleaning	9-39
9-13 Leachate Treatment Options	9-40
9-14 Example of a Groundwater Remediation System	9-42
9-15 Factors Affecting Landfill Gas Generation and Recovery Rates	9-44



FIGURES

(continued)

Figure Number		Page
9-16	Example of a Gas Monitoring Probe	9-45
9-17	Typical Arrangements for Passive Gas Venting	9-46
9-18	Active Gas Control Systems	9-47
9-19	Gas Collection Systems with Wells	9-48
9-20	Examples of Final Covers	9-49
9-21	Waste Densities	9-58



TABLES



Introduction

Table Number		Page
I-1	Municipal Solid Waste Generated in 1990	xxvi

Chapter 1: Public Education and involvement

1-1	Methods of Publicity	1-3
-----	----------------------------	-----

Chapter 2: Facility Siting and permitting

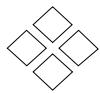
2-1	The Elements of a Public Involvement Plan	2-7
2-2	The Objectives of a Public Involvement Plan	2-8
2-3	Public Information Techniques	2-9
2-4	Participation Techniques	2-10
2-5	Seven Cardinal Rules of Risk Communication	2-11
2-6	Examples of Risk Communication Objectives	2-12
2-7	Risk Management Checklist	2-12
2-8	Key Characteristics of Public Risk Perceptions	2-13

Chapter 3: Factors to Consider

3-1	Projected Per Capita Generation of Municipal Solid Waste by Material, 1988–2010	3-6
3-2	Recyclable Household Waste	3-6
3-3	Advantages and Disadvantages of Bar-Code Monitoring	3-9
3-4	Recyclable Material in the Commercial Waste Stream	3-10
3-5	Projections of Products Generated in the Municipal Waste Stream, 1955 to 2010	3-12
3-6	New Jersey Statewide Recycling Projections: Five-Year Rate	3-13

Chapter 4: Collection And Transfer

4-1	Key Steps in Developing or Modifying a Waste Collection and Transfer System	4-5
4-2	Advantages and Disadvantages of Alternative Funding Mechanisms	4-8
4-3	Advantages and Disadvantages to Alternative Pick-Up Points for Collecting Solid Wastes	4-12
4-4	Factors to Consider in Selecting or Specifying Solid Waste Collection Equipment	4-15
4-5	Advantages and Disadvantages of Transfer Station Types	4-18
4-6	Transfer Station Site Design Considerations	4-21
4-7	Transfer Station Building Components: Design Considerations	4-22
4-8	Formulas for Determining Transfer Station Capacity	4-23
4-9	Transfer Truck and Trailer Systems: Design Considerations	4-25
4-10	Calculations for Waste Collection System Design	4-27
4-11	Steps for Conducting a Time Study	4-29
4-12	Transfer System Costs	4-30
4-13	Rules for Heuristic Routing	4-31



TABLES (continued)

Chapter 5: Source Reduction

Table Number		Page
5-1	Results of the Feather River Company's Polystyrene Peanut Reuse Program	5-16
5-2	Results of Nicolet's Reusable Mug Program	5-16

Chapter 6: Recycling

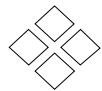
6-1	A 12-Component Recycling Program Plan	6-7
6-2	1992 Tonnages of Selected Recyclables	6-8
6-3	Waste Paper in Thousand Tons, 1992	6-10
6-4	Plastics Packaging Recycling: 1990-1992	6-12
6-5	Selected Organizations Providing Market Listings	6-14
6-6	Commonly Used Price-Setting and Tracking Publications	6-16
6-7	Examples of Recycled Content Mandates	6-18
6-8	Creating Demand for Recyclables: Purchasing Recycled Products	6-20
6-9	Costs and Participation Rates by Container Type	6-26
6-10	Selected Mixed Waste Processing Operations	6-27
6-11	Recovery Levels for Selected Mixed Waste Processing Operations	6-28
6-12	Collection Characteristics	6-31
6-13	Sample Weight to Volume Conversion Factors for Recyclables	6-38
6-14	Model Budget	6-46

Chapter 7: Composting

7-1	Advantages and Disadvantages of Source-Separated Versus Commingling of MSW	7-16
7-2	Ceiling Concentrations for Biosolids	7-27
7-3	Potential Users and Uses of Compost	7-30
7-4	Examples of Compost Quality Guidelines Based on End Use	7-31
7-5	Common Sources of Contaminants in MSW	7-32
7-6	Heavy Metals in Yard Trimmings Compost	7-45
7-7	Pesticide Analysis of Portland, Oregon, Yard Trimmings Compost	7-46
7-8	Examples of Inorganic Constituents in Compost	7-49

Chapter 8: Combustion

8-1	Waste Management Practices 1960-2000	8-1
8-2	Heating Value of Typical Solid Waste Components	8-10
8-3	Waste-to-Energy Facilities Operating in the United States (Mid-1991)	8-18
8-4	RDF Production and Co-Firing Experience	8-23
8-5	Dedicated RDF Boiler Facilities	8-24
8-6	NSPS Emission Standards for All Types of Waste Combustors	8-32
8-7	Minimum Carbon Monoxide Standards for Various Combustion Technologies	8-32
8-8	PSD Significant Emission Rates	8-33
8-9	National Ambient Air Quality Standards	8-35



TABLES

(continued)

Chapter 9: Land Disposal

Table Number	Page
9-1 Typical Densities of Solid Wastes	9-13
9-2 Summary of Density Factors for Landfill Materials	9-14
9-3 Sanitary Landfill Design Steps	9-27
9-4 Changes in Leachate Composition in Different Stages of a Landfill	9-33
9-5 Impact of Soil Surface on Water Runoff	9-34
9-6 Output from HELP Model	9-35
9-7 Groundwater Protection Performance Standards	9-37
9-8 Wisconsin Clay Liner Specifications	9-38
9-9 Typical Landfill Gas Composition	9-43
9-10 Steps for Planting and Maintaining Vegetation on Landfills	9-51
9-11 Site Preparation and Construction Steps	9-53
9-12 Equipment Needs by Daily Tonnage	9-57
9-13 Safety Suggestions for Sanitary Landfill Equipment Operators	9-60
9-14 Procedures for Site Closure	9-62



INTRODUCTION

Volume I of the *Decision Maker's Guide to Solid Waste Management* cites estimates by the U.S. Environmental Protection Agency (USEPA) that 160 million tons of municipal solid waste were generated in the United States in 1989. Since Volume I was published, the estimated annual generation rate has risen to nearly 195.7 million tons (see Table I-1), and it appears that America's propensity for producing waste is not diminishing.

Volume I described a better way of dealing with the growing municipal solid waste problem. That solution, called integrated solid waste management (see Figure I-1), involves a combination of techniques and programs to manage the municipal waste stream. Using the integrated approach, a community can tailor its own unique system to prevent and handle various components of the waste stream in the most economical and environmentally sound manner. In Volume I, readers were introduced to the concept of developing a community integrated waste management system.

Volume II expands the information provided in Volume I. It offers decision makers more detailed information so they can help communities successfully implement integrated solid waste management programs. This volume will assist decision makers and technical professionals who must understand the key technical, legal, economic, political, and social issues that must be addressed to develop effective waste management programs.

Volume II focuses on municipal solid waste management issues. It does not address management of other important waste types, including hazardous waste, municipal sewage sludge, or agricultural residues.



EMERGING ISSUES

Technical requirements for facility siting and operating are becoming more stringent.

Government procurement policies are stimulating recycling markets.

The cost of integrated waste management programs is stimulating interest in source reduction and recycling.

Waste management practices in the United States are continually changing. Public and private activities at the local, state, federal, and even international levels are having major impacts on community waste management programs. Following are just a few examples of emerging issues that will greatly affect waste management decision making.

Technical requirements for siting and operating waste management facilities are becoming more stringent. Federal and state laws require that landfills have engineered safeguards such as liners, leachate collection systems, gas management, and environmental monitoring. New laws require that waste-to-energy facilities have special technology for capturing emissions and that ash residues be specially managed. Standards for work place safety and working conditions are likely for waste management facilities such as recycling centers and composting operations. These new technical requirements will probably increase the cost and the public scrutiny of proposed methods for managing waste.

New state and federal guidelines requiring that governments procure products made from recycled materials are stimulating development of recycling markets. Procurement laws should spur the development of new capacity for recycling a variety of products, especially paper. Market development is expected to increase worldwide, since the sale of recyclable material constitutes a major international market, especially for communities on America's east and west coasts.

In contrast, the true cost of alternative waste collection, processing and disposal options is not yet well understood by most communities and citizens. As these costs become clearer, source reduction and recycling efforts are likely to be more attractive options. Establishing and operating successful solid waste management programs requires the existence of steady markets for recycled products, compost, and the energy produced from WTE plants. This in turn may require increasing the demand for such products. Communities may also need to consider looking for alternative funding sources to support source reduction, recycling, and other programs. How much voters and waste generators are willing to pay for integrated waste management programs has not yet been widely determined.

Table I-1

Municipal Solid Waste Generated in 1990 (in millions of tons)

6.7%*	Glass	13.2
6.7%	Food scraps	13.2
8.3%	Plastics	16.2
8.3%	Metals	16.2
14.6%	Rubber, leather, textiles, wood	28.6
17.9%	Yard trimmings	35.0
37.5%	Paper and paperboard	73.3
	TOTAL WEIGHT:	195.7

*Percent of total waste generated.

Source: USEPA, *Characterization of Municipal Solid Waste in the United States: 1992 Update*

Despite major uncertainties facing decision makers in the United States, there will be a continuing need to address solid waste management issues in a timely manner. Decision makers and technical professionals considering how best to manage community waste must be aware of changing conditions and emerging issues, but they should not be deterred from developing waste management projects. This volume of the *Decision Makers' Guide* will help these persons understand the issues and develop successful integrated waste management programs.

Figure I-1

Hierarchy of Integrated Solid Waste Management

Source Reduction

Source reduction tops the hierarchy because of its potential to reduce system costs, prevent pollution, consume resources, and increase efficiency. Source reduction is discussed in more detail in Chapter 5. Source reduction programs are designed to reduce both the toxic constituents in products and quantities of waste generated. Source reduction is a front-end waste avoidance approach that includes strategies such as designing and manufacturing products and packaging with minimum volume and toxic content and with longer useful life. Businesses, institutions, and citizens may also practice source reduction through selective buying and the reuse of products and materials.

Recycling

Recycling (including composting) is the second step in the hierarchy. It involves collecting materials, reprocessing/remanufacturing, and using the resulting products. Recycling and composting can reduce the depletion of landfill space, save energy and natural resources, provide useful products, and provide economic benefits. These options are discussed in more detail in Chapters 6 and 7.

Waste Combustion and Landfilling

Waste combustion and landfilling are at the bottom of the hierarchy—USEPA does not rank one of these options higher than the other, as both are viable components of an integrated system. Waste combustion, discussed in Chapter 8, reduces the bulk of municipal waste and can provide the added benefit of energy production. State-of-the-art technologies developed in recent years have greatly reduced the adverse environmental impacts associated with incineration, and although waste combustion is not risk-free, many communities are relying on this waste management alternative.

Landfilling, discussed in Chapter 9, is necessary to manage nonrecyclable and noncombustible wastes, and is the only actual waste "disposal" method. Modern landfills are more secure and have more elaborate pollution control and monitoring devices than earlier landfills. Environmental concerns at properly managed landfills are greatly reduced. Also, many new landfills are using methane recovery technologies to develop a marketable product.

Source: USEPA

EPA's hierarchy of integrated solid waste management includes:

- **Source reduction**
- **Recycling**
- **Waste combustion and landfilling.**

REFERENCES

USEPA. 1992. Characterization of Municipal Solid Waste in the United States: 1992 Update. Washington, D.C. EPA/530-R-92-019 (July).

USEPA. 1989. Decision Makers Guide to Solid Waste Management. Washington D.C. EPA/530 SW-89-072 (November).

